Degree in Observational Astronomy

By Brad Young, Astronomy Club of Tulsa

A very long time ago I wrote up a curriculum for an imaginary bachelor's degree in Observational Astronomy. I found it the other day and reproduced and posted it here at my website. It has ideas for classes and labs, including the corresponding Astronomical League observing program and useful books. Note that some of the books were old even then, but later editions or similar texts should be available today. To be honest, for the basic stuff that doesn't become out of date, I prefer the older texts.

I know that there are plenty of colleges out there that have programs in astronomy, and here locally our community college offers a course in astronomy that has been taught by members of our astronomy club. However, they tend to be either introductory, without discussing observation methods, or are geared towards students destined to be professional astronomers. This imaginary curriculum was meant more to list all the subjects useful to the ambitious amateur. However, this discussion isn't about that curriculum, but more about the ideas and knowledge in it that can be used to improve your observational skills.

Choosing Improvement Instead of Derision

> "Advice is like snow - the softer it falls, the longer it dwells upon, and the deeper it sinks into the mind." - Samuel Taylor Coleridge.

Right from the start, I want to clarify I don't intend to state that you're not a "real" amateur unless you know all these subjects and could do everything manually, which was a common theme when I was starting out as an amateur astronomer. Back then, if you didn't build your own scope, you weren't dedicated. And if you didn't eschew setting circles and star hop, some people didn't consider you a true amateur. Instead of adopting that attitude, I would like to look at things from a positive standpoint, i.e., the skills you can choose to learn that may help.

Many people today start out in amateur astronomy with computer-controlled imaging equipment and do not take the time to learn some of the basics of how the sky works and what you can do with your observations to improve your knowledge and possibly provide information used by professional astronomers. There is nothing wrong with this, but starting out letting the computer find everything, and not having basic skills may hinder your growth as an amateur.

Celestial Mechanics

> "We see the sky turning around us every day,
> but we are the ones who are turning."
>
> — Carlo Rovelli, The Order of Time

If we look at the many subjects that most general astronomy classes cover, you would be introduced to celestial mechanics. Celestial mechanics is the study of how the sky moves and works, including the coordinate systems that are used to find the position of objects. This would certainly be worth the time and effort to learn no matter what your interest in astronomy may be. Knowing how the sky rotates each night, and changes with the seasons will help you determine what targets are available to you, how high in the sky they are, etc.

Learning the constellations will also help you while you're out under the stars and looking for the approximate location of your target. Knowing how the planets move along the ecliptic and when they are best to observe is also an important skill to have.

The coordinate systems include:

- Right ascension and declination, the extension of longitude and latitude into the sky.
- Ecliptic latitude and longitude, based on the path of the sun and planets.
- Galactic latitude and longitude, based on the shape of the Milky Way.

Most positions will be given in the first set using RA and declination, but it may help to know at least the basis for the other two in case you run across them.

Another subject in astronomy is orbital mechanics. Knowing a few fundamental values, the position of a planet, asteroid, or comet can be determined far into the future. In the reverse, with three good positions on a new comet or asteroid, the orbit can be determined and described by the same values. These are called the Keplerian elements (named for Johannes Kepler) and include:

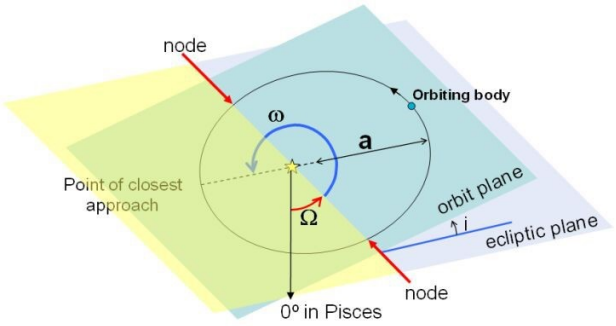
- M = mean anomaly at the selected epoch, the average change in position during the interval from perihelion until the epoch date and time.
- Ω = ascending node, the longitude where the object crosses the ecliptic going north.
- ω = argument of perihelion, difference in longitude from Ω to perihelion.
- ι = inclination, the maximum vertical deviation of the orbit from the ecliptic.

- ε = eccentricity, the deviation of the elliptical orbit from a circle.
- a = semi-major axis, the average distance from the sun.

Note that perihelion is the point in the orbit closest to the sun, and epoch is a date selected for convenience and used for all objects that year.

For a comet, the time of perihelion T and the perihelion distance Q may replace M, epoch and a.

Seeing the situation in a diagram may help:



It's not critical that you know how to use these elements to calculate positions in the sky, but you may have to input these values or use them on occasion and it helps to know what they are and why they are used.

Other important things to know include atmospheric phenomenon and transient apparitions. The zodiacal light and gegenschein are among the effects that may interfere with observing or imaging but are also amazing to see visually. And you will be best served if you know when there will be a meteor shower and how comets appear in the sky, how they travel and what to expect when you observe them.

Equipment Selection and Methods

> But choose wisely, for while the true [scope] will bring you [the sky], the false [scope] will take it from you. Grail Knight (sort of)

Of course, each type of optical and camera assembly will have individual requirements, but to determine the best setup for your interest, it would be good to know how all equipment works including the different types of telescopes, the different types of cameras and mounts, and how they all work together to provide images. Or, if you are staying with only visual observations, it will be critical for you to know how telescope operates and what eyepieces, filters, etc. are needed for best results.

Planetary, lunar, solar, and deep sky observing all have different requirements for equipment and you would be best off to know how these different targets respond to different equipment. There are also subtle differences in how you observe each type of object, and having a better understanding of this will aid you in either imaging or visual observation.

Also, there are also highly specialized observing methods for occultations, photometry, astrometry, and spectroscopy. Additionally, some amateurs track satellites either visually or by radio, and radio astronomy can be done by amateurs to study all sorts of objects that have their best view in that part of the spectrum. Most of this equipment is at least moderately difficult to setup, much of it requiring the user to build or modify the standard equipment.

High End Equipment and No End Knowledge

Origins Observatory by Celestron

Recently, smart scopes like the Celestron Origins Observatory have been developed to rid the user of any need to know where they are, what time it is, and allow a minimal setup, running the scope from their smartphone. This makes observing automatic to the point of nearly point and click. Very useful, but it is easy to ignore learning all the basic knowledge I described earlier and just start cold.

Good Idea – But How Do I Learn?

> "I am always doing that which I cannot do, in order that I may learn how to do it." - Pablo Picasso

So, I have pushed you to learn about these subjects, especially the basic ones about how the sky works, the constellations, and the coordinate systems used. I believe this would be a huge help in whatever equipment and type of targets you choose. So, the question is, how are you supposed to learn these concepts?

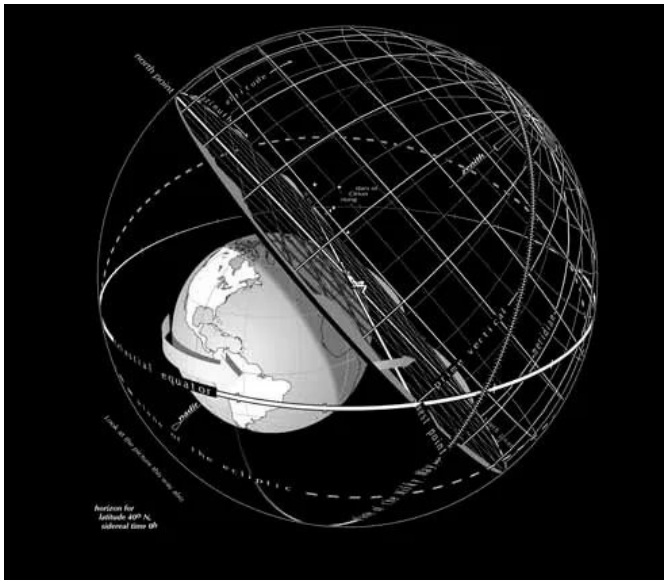


Figure 4: Example from Astronomical Companion of sky above the person laying down (in Turkey?)

Open universities provide free classes on many astronomy subjects. For instance, https://www.classcentral.com/subject/astronomy?free=true&free-certificate=true list free online classes, showing the provider, subject, and workload. Some even provide a certificate.

There are several websites that provide free projects and lessons for homeschoolers, such as https://skyandtelescope.org/homeschool-resources/. There is no reason why anyone else should know you are using these, and they do explain the concepts well, especially the items intended for high school students.

The curriculum posted to my website has books that I thought would be useful and probably still are. Some of them were published a while back so there may be later additions or more modern treatises on these things but many of the basics have not changed, such as constellations and the movements of the stars and planets (Figure 4.)

Newer ones that come to mind are Guy Ottewell's *Astronomical Companion*, and *The Stars: A New Way to See Them*, by H.A. Rey. When you start to view more challenging objects in the deep sky, David Levy has written several good guide books for specific types of objects, as has Steven O'Meara.

Close the Book and Laptop

Using these books and courses will help you start out, but when you have a chance, it is most useful to spend time under the sky. Even on nights that don't merit using the telescope, working out how these fundamental concepts of star rising and setting, the motion of the planets, or just the glow of the sunset all around the horizon is an investment in knowing the sky.

Observing with and talking to some of the other people in your club may help you to work through learning about these useful subjects. Don't be embarrassed to ask even the simplest questions; someone there will be willing and able to help or know who can.

Electronically aided astronomy (EAA) and the other devices that simplify seeing the universe are a wonderful leap in technology to jump start people into observing and imaging without much initial effort. But I tend to believe that putting in that effort to learn the basics has made me a better amateur astronomer. Learning the basics would probably be very useful to anyone using any technology to do amateur astronomy today. And I can assure you that it will make you enjoy the night even more.